

TUBE PUMP AND LIQUID INJECTION APPARATUS

BACKGROUND OF THE INVENTION

5 The present invention relates to tube pumps and liquid injection apparatuses, and, more particularly, to tube pumps and liquid injection apparatuses that operate silently.

10 Conventionally, a tube pump drawing fluid from one end and discharging it from another by generating negative pressure is known. Since this type of pump is configured simple and compact, the pump is used in different types of apparatuses that involve the use of fluid.

15 For example, the tube pump is used in an inkjet recording apparatus (a liquid injection apparatus), which discharges (injects) ink (liquefied fluid) to a recording sheet through a nozzle of a recording head, forming an image on the sheet. The tube pump draws ink from the nozzle when the recording
20 head is cleaned for ensuring a smooth operation of the recording head (for example, Japanese Laid-Open Patent Publications No. 2001-301195 and No. 7-253082).

25 As illustrated in Figs. 19 and 20, in the tube pumps described in the aforementioned documents, a flexible tube 1 is accommodated in a cylindrical case 2. A roller 3 operates to press and squeeze the tube 1 against an inner wall 2a of the case 2. The position at which the tube 1 is pressed by the roller 3 constantly shifts from an upstream position to a
30 downstream position of the tube 1. The tube pump thus generates negative pressure at an upstream section of the tube 1. The ink is thus drawn from the upstream section of the tube 1 and is discharged from the downstream side of the tube 1.

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However, these tube pumps (Japanese Laid-Open Patent Publication No. 2001-301195 corresponds to Fig. 19 and Japanese Laid-Open Patent Publication No. 7-253082 corresponds to Fig. 20) include overlapped portions 1a, 1b, at which a
5 certain portion of the tube 1 crosses and overlaps a different portion of the tube 1 inside or outside the case 2. This arrangement enlarges the space occupied by the tube 1, thus preventing the tube pumps from being formed compact.

10 Further, in some color inkjet recording apparatuses, two flexible tubes 1, one for color ink and the other for black, are provided integrally with each other. In this case, the tube pump has four overlapped portions 1a, 1b of the tube 1. The space occupied by the overlapped portions 1a, 1b is thus
15 further enlarged, worsening the aforementioned problem.

To solve the problem, an opening 2b extends through a portion of the inner wall 2a of the case 2, as shown in Fig. 21. The tube 1 is passed through the opening 2b without
20 forming overlapped portions. The ends of the tube 1 are then separated from each other without interfering with each other.

However, in this configuration, at a position corresponding to the opening 2b of the case 2 (as indicated by
25 the broken line in Fig. 21), the roller 3 quickly moves from the downstream portion to the upstream portion along the outer circumferential surface of the tube 1. At this stage, since the two portions have greatly different surface conditions, a noise may be caused due to an impact between the roller 3 and
30 the tube 1. Further, when the roller 3 proceeds from the downstream portion to the upstream portion, squeezing of the tube 1 by the roller 3 may become insufficient. If this is the case, the interior of the tube 1 may instantly become continuous, releasing the negative pressure. This problem
35 equally occurs in the tube pump of Japanese Laid-Open Patent

SUMMARY OF THE INVENTION

5 Accordingly, it is an objective of the present invention to provide an improved tube pump and liquid injection apparatus that operate without producing noise.

10 To achieve the foregoing and other objectives and in accordance with the purpose of the present invention, the invention provides a tube pump comprising a flexible tube in which a fluid passage is formed, an accommodating case for accommodating the flexible tube, a pressing member revolving in the accommodating case, and an auxiliary member formed in
15 the vicinity of the opening of the accommodating case. The tube extends along an inner wall of the case. The inner wall has an opening, and the tube extends to the exterior of the case through the opening. The tube has a first portion and a second portion, which are located close to each other in the
20 vicinity of the opening. The pressing member moves from the first portion to the second portion along the flexible tube while pressing and squeezing a portion of the tube against the inner wall of the case. This enables a fluid to flow from the first portion to the second portion in the fluid passage. The
25 auxiliary member has an auxiliary surface. When the pressing member passes the vicinity of the opening of the case, the auxiliary member transfers the pressing member from the second portion to the first portion via the auxiliary surface.

30 BRIEF DESCRIPTION OF THE DRAWINGS

 The characteristics of the present invention believed to be novel will become apparent in the attached claims. The invention, together with objectives and advantages thereof,
35 may best be understood by reference to the following

description of the presently preferred embodiments together with the accompanying drawings in which:

Fig. 1 is a perspective view showing an operating portion
5 of an example of an inkjet recording apparatus according to a first embodiment of the present invention;

Fig. 2 is an elevation view schematically showing a main mechanism of the inkjet recording apparatus of Fig. 1;

Fig. 3 is a perspective view showing a main part of the
10 mechanism of Fig. 2;

Fig. 4 is an exploded perspective view showing the configuration of a main portion of the inkjet recording apparatus of Fig. 1;

Fig. 5 is a partially cross-sectional plan view showing
15 the configuration of Fig. 4;

Fig. 6 is an exploded perspective view showing the configuration of Fig. 4;

Fig. 7 is a perspective view showing a main part of the configuration of Fig. 4;

Fig. 8 is an elevation view explaining the function of
20 the configuration of Fig. 4;

Fig. 9 is a plan view explaining the function of the configuration of Fig. 4;

Fig. 10 is an elevation view explaining the function of
25 the configuration of Fig. 4;

Fig. 11 is a plan view explaining the function of the configuration of Fig. 4;

Fig. 12 is a partially cut-away plan view explaining the operation of the configuration of Fig. 4;

Fig. 13 is a partially cut-away plan view explaining the
30 operation of the configuration of Fig. 4;

Fig. 14 is a partially cut-away plan view explaining the operation of the configuration of Fig. 4;

Fig. 15 is a partially cross-sectional plan view showing
35 the configuration of a main portion of an inkjet recording

apparatus according to a second embodiment of the present invention;

Fig. 16 is a partially cross-sectional plan view explaining the operation of the configuration of Fig. 15;

5 Fig. 17 is a partially cross-sectional plan view showing the configuration of a main portion of an inkjet recording apparatus according to a third embodiment of the present invention;

10 Fig. 18 is a partially cross-sectional plan view explaining the operation of the configuration of Fig. 17;

Fig. 19 is a partially cross-sectional plan view showing a prior art;

Fig. 20 is a plan view showing another prior art; and

15 Fig. 21 is a partially cross-sectional plan view showing an improvement of the technique of Fig. 20.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

20 A first embodiment of the present invention will now be described with reference to the attached drawings. Figs. 1 to 14 show an example of an inkjet recording apparatus, a first embodiment of a liquid injection apparatus including a tube pump according to the present invention.

25 The configuration of the apparatus will be first explained. As illustrated in Figs. 1 and 2, an inkjet recording apparatus 10 has a carriage 12, in which an ink cartridge 11 including three primary color inks and a black ink, is accommodated. The carriage 12 is reciprocated by the
30 drive force of a motor 14 transmitted via a belt 15, as guided by a guide 13 along a main scanning direction. The inkjet recording apparatus 10 discharges (injects) ink (liquefied fluid) from the ink cartridge 11 through a non-illustrated nozzle, which is provided in a recording head 16 (a liquid
35 injection apparatus) formed at the bottom surface of the

carriage 12.

The inkjet recording apparatus 10 feeds a recording sheet P to a platen 17 that extends in the main scanning direction along which the carriage 12 moves. The inkjet recording apparatus 10 discharges and injects ink through the nozzle of the recording head 16, in a selective manner in correspondence with printing data. An image such as a character is thus formed on a recording surface of the recording sheet P. The ink discharging method of the recording head 16 is nonrestrictive and may be a pressing method that involves displacement of a piezoelectric (piezo) element or heating and vaporization with a heater.

In the inkjet recording apparatus 10, a head cleaning device 21 is located at a position near one end of the main scanning direction (a cleaning position) in the exterior of an image forming area. The head cleaning device 21 includes a cap mechanism 23 and a tube pump 25. As lifted by a non-illustrated lift means, the cap mechanism 23 presses a cap 22 against the nozzle forming surface at the bottom side of the recording head 16, defining a sealed space. A flexible tube 24 is accommodated in the tube pump 25 to draw and discharge fluid. The tube 24 has an upstream portion 24a, or a drawing side, and a downstream portion 24b, or a downstream side. The upstream portion 24a is connected with the sealed space formed by the cap mechanism 23. The downstream portion 24b, which is a discharge side, is connected with the interior of a discharged ink reservoir 26.

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To assure that a smooth recording operation is performed repeatedly, the head cleaning device 21 is operated to activate the cap mechanism 23 and the tube pump 25 at predetermined timings. That is, the head cleaning device 21 draws the inside of the sealed space formed by the cap 22

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through a passage 24c (Fig. 3) of the tube 24, in order to depressurize the sealed space. In this manner, the head cleaning device 21 performs head cleaning, or draws the ink from the nozzle of the recording head 16 and discharges the ink to the discharged ink reservoir 26. The cap 22 is shaped as a square frame such that the sealed space is formed by pressing the upper edge of the cap 22 against the nozzle forming surface of the recording head 16. A sponge sheet 29 is fixed to the bottom of the cap 22 to suppress splashing of the ink drawn from the nozzle of the recording head 16.

As illustrated in Fig. 3, the flexible tube 24 is shaped as a double tube having two tubes 27, 28 aligned in parallel. The tube 24 is formed as one body from a flexible material such as silicone rubber through molding.

With reference to Fig. 4, the tube pump 25 is formed simply by assembling the tube 24, a lidded cylindrical, accommodating case 31 and a pressing device 41. The case 31 accommodates an intermediate portion of the tube 24 in such a manner that the tube 24 extends along an inner wall 31a. The pressing device 41 presses and squeezes the tube 24 against the inner wall 31a of the case 31.

An opening 32 is formed in the case 31 by cutting a portion of the inner wall 31a. The tube 24 may be passed through the opening 32 (to the interior of the case 31 and then to the exterior). An attaching portion 34 is formed outside the opening 32. A fixing block 33 for fixing the tube 24 is fitted in the attaching portion 34 or secured to the attaching portion 34 with a screw.

The flexible tube 24 has a first portion and a second portion that are located close to each other in the vicinity of the opening 32. The upstream portion 24a includes the

first portion and a first extending portion that extends from the first portion to the exterior of the case 31 through the opening 32. The downstream portion 24b includes the second portion and a second extending portion that extends from the
5 second portion to the exterior of the case 31 through the opening 32. The first extending portion is connected with the aforementioned sealed space. The second extending portion is connected with the discharged ink reservoir 26.

10 The fixing block 33 has a groove 33a. The attaching portion 34 has a projection 34a. The groove 33a and the projection 34a extend parallel with the axis of the case 31 (direction A in Fig. 4). By fitting the projection 33b in the groove 33a, the intermediate portion of the tube 24, which is
15 supported by the fixing block 33, is positioned in and secured to the case 31 as extending along the inner wall 31a.

The case 31 includes an auxiliary member 101 formed at a position corresponding to the opening 32. The auxiliary
20 member 101 is shaped as a substantially triangular pole. The axial dimension of the auxiliary member 101 is substantially equal to that of the inner wall 31a. The auxiliary member 101 is formed from a highly deformable elastic material. The auxiliary member 101 is located between the first portion and
25 the second portion and has a substantially triangular cross-sectional shape. As viewed in Fig. 5, curved surfaces are formed along two slanted sides 101a, 101b of the auxiliary member 101, which extend along the inward portions of the outer circumferential surface of the tube 24 passed through
30 the opening 32 in the case 31, or separate from the inner wall 31a (the sides 101a, 101b may be flat surfaces). A base surface 101c, located between the sides 101a, 101b, has a flat surface extending substantially parallel with a plane 35
35 extended from the inner wall 31a (indicated by the double dotted broken line in Fig. 5). The side 101a, which serves as

a first surface, faces the first portion of the tube 24. The side 101b, which serves as a second surface, faces the second portion. The base surface 101c of the auxiliary member 101 forms an auxiliary surface connected smoothly with the inward portions of the outer circumferential surface of the portions of the tube 24 passed through the opening 32 (the first, and second portions) in the case 31.

The fixing block 33 accommodates the flexible tube 24 such that the tubes 27, 28 are aligned in parallel along the axial direction of the case 31. The tube 24 is fixed in a curled manner forming a substantial U shape (substantially in an arched manner), such that the flow direction of fluid is turned accordingly. With reference to Fig. 5, when the tube 24 is accommodated in the case 31, the ends of the tube 24 project from the fixing block 33 (not illustrated in the drawing) while the portion of the tube 24 in the case 31 extends along the inner wall 31a. The projecting ends of the tube 24 are separated from each other such that the tube 24 forms a Ω shape. This arrangement makes it unnecessary to overlap one portion of the tube 24 with another along the axial direction of the case 31. The case 31 thus becomes compact. Further, although the flexible tube 24 includes the tubes 27, 28 formed as one body, the tube 24 may have a single tube or three or more tubes. Also, the tubes may be simply aligned in parallel without forming one body.

The pressing device 41 has a rotary disk 42 with a rotary shaft 43. The rotary shaft 43 is rotationally supported by a shaft hole 31c formed at the center of the bottom 31b of the case 31. A support 51 is connected with the disk 42 such that the support 51 is rotated substantially integral with the disk 42 in the case 31. A roller 44 is rotationally supported by the support 51. That is, the disk 42 and the support 51 support the roller 44 in such a manner that the roller 44 is

located in the vicinity of the inner wall 31a of the case 31. The disk 42 is actuated by a non-illustrated motor engaged with a flat cut-out portion 43a formed at one end of the rotary shaft 43.

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In other words, by enabling the disk 42 to rotate around the axis A (the cylindrical axis A of the case 31), the pressing device 41 operates to roll (revolve) the roller 44 along the inner wall 31a of the case 31. That is, while
10 pressing and squeezing the tube 24 against the inner wall 31a of the case 31, the roller 44 shifts the position at which the tube 24 is pressed along the revolving direction of the roller 44. The roller 44, functioning as a pressing member, revolves around the axis A.

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In this manner, the tube pump 25 depressurizes (produces negative pressure in) the upstream portion 24a, which is connected with the sealed space formed by the cap mechanism 23. The ink is thus drawn from the nozzle of the recording
20 head 16. Meanwhile, the pump 25 pressurizes the downstream portion 24b, which is connected with the discharged ink reservoir 26, urging the drawn ink to be discharged.

More specifically, with reference to Fig. 6, the pressing
25 device 41 has a simple structure configured by assembling the rotary disk 42, the roller 44, the support 51, a coil spring 61, and a stopper 62.

The support 51 is formed integrally by connecting an
30 upper plate 52 with a lower plate 53, which oppose each other, by means of a connecting body 54. A C-shaped guide groove 55 extends through the upper plate 52. The guide groove 55 has an arched shape that corresponds to a half of a substantial circumference of the disk 42 around the axis A. As shown in
35 Fig. 8, the lower plate 53 has a small diameter portion 56.

The outer circumferential surface of the small diameter portion 56 is located at a circumferential position corresponding to that of an inner circumferential surface 55a of the groove 55. Also, the outer circumferential surface of the small diameter portion 56 is shaped in correspondence with the inner circumferential surface 55a of the groove 55. The remainder of the lower plate 53 has a relatively large diameter.

10 A retreat position T is located at a proximal end of a path indicated by arrow D1 in Fig. 6, while an operating position S is located at a distal end of the path. With reference to Figs. 6 and 8, the inner circumferential surface 55a of the groove 55 and the outer circumferential surface of the small diameter portion 56 of the support 51 extend to be radially spaced from the axis A of the disk 42, gradually from the retreat position T toward the operating position S.

20 In the support 51, one of the rotary shafts of the roller 44, or a rotary shaft 44b, is supported by and guided in the guide groove 55 of the upper plate 52. The other rotary shaft of the roller 44, or a rotary shaft 44c (Figs. 8 and 10), is guided along the outer circumferential side of the small diameter portion 56. A roller portion 44a of the roller 44 is clamped between the upper plate 52 and the lower plate 53 such that the roller portion 44a is permitted to be revolved in a substantially circumferential direction.

Therefore, the roller 44 is rotationally supported, with the roller portion 44a maintained in a state parallel with the axis A of the disk 42. The roller 44 is allowed to move within a predetermined range (between the retreat position T and the operating position S of the groove 55 of Fig. 6) in a substantially circumferential direction around the axis A.

35 The roller 44 is capable of reciprocating between the retreat

position T and the operating position S.

In other words, when the disk 42 is rotated in a direction opposite to the direction indicated by arrow D1 of Fig. 6, the roller 44 of the pressing device 41 is urged to move from the retreat position T to the operating position S in the groove 55. The roller 44 thus becomes separated from the axis A of the disk 42 gradually in the radial direction. Accordingly, the pressure for squeezing the tube 24 extending along the inner wall 31a of the case 31 is increased.

The support 51 also includes an attaching groove 55b that extends radially outward from the outer circumferential surface of the groove 55 of the upper plate 52. By fitting the rotary shaft 44b of the roller 44 in the attaching groove 55b, the rotary shaft 44c of the roller 44 is easily positioned at a position abutted by the outer circumferential surface of the small diameter portion 56. Although a single roller 44 is employed in the illustrated embodiment, the present invention is not restricted to this structure and may include two or more rollers.

Further, a through hole 51a extends through the centers of the upper plate 52, the lower plate 53 and the connecting body 54 of the support 51. A cut-out portion 51b is defined in a predetermined area of the upper plate 52 and the connecting body 54 at a position opposed to the guide groove 55. The cut-out portion 51b extends to a position in the vicinity of the lower plate 53. The through hole 51a is capable of receiving the rotary shaft 43 of the disk 42 that is passed through a body 61a of the coil spring 61. A cross section of the cut-out portion 51b perpendicular to the axis A of the disk 42 has an arcuate shape with respect to the axis A.

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A projection 57 projects from the side wall of the cut-out portion 51b at the side of the distal end of the guide groove 55 (the operating position S). The projection 57 extends parallel with the axis A of the disk 42 and reaches the position spaced from the bottom of the lower plate 53. An engaging recess 57a is defined between the projection 57 and the bottom surface of the lower plate 53. The engaging recess 57a is capable of engaging with an arm 61b of the coil spring 61, with the rotary shaft 43 of the disk 42 passed through the body 61a.

The disk 42 includes an engaging projection 46 that projects from a lower side 42a of the disk 42 (Fig. 7). The engaging projection 46 is received in the cut-out portion 51b of the support 51. With reference to Fig. 7, the engaging projection 46 includes a first block 46a, a second block 46b, and a third block 46c.

The first block 46a is formed in an arcuate shape around the axis A of the disk 42, with the axial dimension and diameter equal to those of the upper plate 52. The angle defined by the arcuate shape (the extending angle) is selected such that the first block 46a has a smaller cross section than that of the cut-out portion 51b of the support 51. The second block 46b has an arcuate shape with the extending angle equal to that of the first block 46a. However, the diameter of the second block 46b is equal to that of the connecting body 54 of the support 51. The axial dimension of the second block 46b is larger than that of the first block 46a. The third block 46c projects from an end of the second block 46b spaced from the axis A of the disk 42. The third block 46c is shaped as a triangular pole such that, when located in the cut-out portion 51b of the cut-out portion 51b of the support 51, the third block 46c projects parallel with the axis A of the disk 42 at a side spaced from the projection 57.

Thus, as viewed in Fig. 7, the left sides of the first to third blocks 46a to 46c are formed as one continuous flat surface. This enables the projection 46 of the disk 42 to
5 contact a corresponding wall of the cut-out portion 51b of the support 51 (the side opposed to the projection 57) in a surface contact manner. The projection 46 is thus capable of pressing uniformly. Further, the opposed right side of the projection 46 includes a step 46d formed between the second
10 block 46b and the third block 46c. The step 46d is arranged to receive an arm 61c of the coil spring 61, with the arm 61b of the coil spring 61 engaged with the engaging recess 57a of the support 51. In this manner, the resilient force produced by the coil spring 61, with the rotary shaft 43 of the disk 42
15 passed through the body 61a, urges the projection 46 of the disk 42 and the projection 57 of the support 51 away from each other. Although the illustrated embodiment employs the coil spring 61, the present invention is not restricted to this structure. Obviously, the coil spring 61 may be a plate
20 spring, a spring, or a rubber member.

The stopper 62 is shaped as a disk with a relatively small diameter. A shaft hole 63 is formed in the stopper 62 for supporting the rotary shaft 43 of the disk 42. The shaft
25 hole 63 has a flat portion 63a that is engaged with a cut-out portion 43b of the shaft 43, opposed to a cut-out portion 43a. The shaft hole 63 is thus engaged with the rotary shaft 43 such that the shaft hole 63 and the rotary shaft 43 are prohibited from rotating relative to each other. This
30 structure connects the stopper 62 with the disk 42 such that the stopper 62 is rotated integrally with the disk 42.

Further, the disk 42 has a circular hole 47a, and the stopper 62 has a circular hole 67a. An elongated hole 47b is
35 formed in the disk 42 and extends along a circumference around

the circular hole 47a. In the same manner, an elongated hole 67b is formed in the stopper 62 and extends along a circumference around the circular hole 67a. A plurality of projections 58a, 58b project from an upper side of the upper plate 52 and a lower side of the lower plate 53 of the support 51 (only those of the upper plate 52 are shown in Fig. 6) at corresponding positions, as viewed in Fig. 6. By engaging the projections 58a and 58b of the support 51 respectively with the circular hole 47a and the elongated hole 47b, the disk 42 and the stopper 62 are allowed to rotate relative to each other in a range defined by the elongated holes 47b, 67b. At the same time, this structure enables the support 51 to be rotated substantially integral with the disk 42 and the stopper 62.

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The assembling process of the tube pump 25 will hereafter be explained. First, as shown in Fig. 6, the support 51 and the roller 44 are prepared. The rotary shaft 44b of the roller 44 is fitted in the attaching groove 55b of the guide groove 55 of the upper plate 52 of the support 51. The rotary shaft 44b is thus placed in contact with the inner circumferential surface 55a of the guide groove 55. In this state, the rotary shaft 44c is abutted by the outer circumferential surface of the small diameter portion 56 of the lower plate 53. This structure allows the roller 44 to be freely rotated (rotated on its axis) and rolled (moved, or revolved, along a circumferential direction of the lower plate 53).

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Next, the rotary disk 42 and the coil spring 61 are prepared. The rotary shaft 43 of the disk 42 is passed through the body 61a of the coil spring 61. With the rotary shaft 43 passed through the coil spring 61, the arm 61c of the coil spring 61 is engaged with the step 46d of the projection 46, which is located between the second block 46b and the

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third block 46c. The rotary shaft 43 of the disk 42 is then inserted in the through hole 51a of the support 51. Further, the arm 61c of the coil spring 61, which is located at the side of the disk 42, is brought closer to the opposite arm 61b. Meanwhile, the arm 61b is then engaged with the engaging recess 57a, which is defined by the projection 57 of the support 51. At the same time, the projection 58a of the support 51 is fitted in the circular hole 47a of the disk 42 and the projection 58b of the support 51 is fitted in the elongated hole 47b of the disk 42. The rotary disk 42 and the support 51 are thus connected with each other.

The stopper 62 is then prepared. The rotary shaft 43 of the disk 42 projecting from the lower plate 53 of the support 51 is fitted in the shaft hole 63 of the stopper 62, such that the cut-out portion 43b is engaged with the flat portion 63b. At the same time, as in the connection between the rotary disk 42 and the support 51, a non-illustrated projection of the support 51 is fitted in the circular hole 67a and another in the elongated hole 67b. The stopper 62 is thus connected with the disk 42 and the support 51, and the assembling process of the pressing device 41 is completed.

As shown in Fig. 8, when the pressing device 41 in the assembled state is free from the force acting to rotate the disk 42 and the support 51 relative to each other, the resilient force produced by the arms 61b and 61c, which operate to be spaced from each other, urges the projection 46 of the disk 42 to be spaced from the projection 57 of the support 51. The projection 46 thus uniformly presses the corresponding wall of the cut-out portion 51b of the support 51. In this state, with the projection 58a of the support 51 engaged with the circular hole 47a of the disk 42, the resilient force of the coil spring 61 acts in a direction indicated by the arrow of Fig. 9 around the projection 58a.

Thus, if no external force is applied, the projection 58b is located at the right end of the elongated hole 47b of the disk 42, as viewed in Fig. 9.

5 With reference to Fig. 10, if the disk 42 and the support 51 of the pressing device 41, or the roller 44, receive the force causing the arms 61b, 61c to approach each other against the force of the coil spring 61, the projection 46 of the disk 42 and the projection 57 of the support 51 approach each
10 other. In this state, with the projection 58a of the support 51 engaged with the circular hole 47a of the disk 42, the support 51 is urged to rotate relative to the disk 42, in a direction indicated by the arrow of Fig. 11 around the projection 58a. The projection 58b is thus located at the
15 left end of the elongated hole 47b of the disk 42, as viewed in Fig. 11.

 In other words, when the roller 44 of the pressing device 41 is located at the operating position S in the guide groove
20 55 of the support 51 (Fig. 6) and is free from any type of force, the roller 44 is placed at the position most spaced from the axis A of the disk 42, with reference to Fig. 8. Further, when the force acting to pivot the projection 58b of the support 51 in the elongated hole 47b of the disk 42
25 against the resilient force of the coil spring 61 is applied to the roller 44 located at the operating position S, the roller 44 is placed at a position close to the axis A of the disk 42, with reference to Fig. 10.

30 That is, the projection 58b of the support 51 is permitted to pivot in the elongated hole 47b of the disk 42 in accordance with the force acting on the roller 44. The roller 44 of the pressing device 41 is thus moved toward or away from the axis A of the rotary disk 42 in accordance with the force
35 (the reactive force) acting on the roller 44. This structure,

as will be described later, enables the force of the roller 44 acting to press the flexible tube 24 against the inner wall 31a of the case 31 (the pressing force) to be adjusted by the resilient force of the coil spring 61. Further, if the roller 44 of the pressing device 41 receives the force acting in the direction opposite to the direction along which the guide groove 55 extends beyond the operating position S, the roller 44 is retreated to the retreat position T (Fig. 6) in the guide groove 55 of the support 51, the position closest to the axis A of the disk 42.

Next, as illustrated in Fig. 4, the groove 33a of the attaching portion 34 of the case 31 is engaged with the projection 34a of the fixing block 33, to which the flexible tube 24 is fixed. At this stage, the tube 24 is passed through the space between the periphery of the opening 32 and the slanted sides 101a, 101b of the auxiliary member 101, such that both ends of the tube 24 are separated from each other. The intermediate portion of the tube 24 is thus placed along the inner wall 31a of the case 31.

Afterwards, the pressing device 41 is inserted in the space surrounded by the tube 24 from the side corresponding to the stopper 62, or the lower plate 53. The distal end of the rotary shaft 43 of the disk 42 is rotationally fitted in the shaft hole 31c of the bottom 31b of the case 31, thus completing the assembly of the tube pump 25. In this state, the roller 44 of the pressing device 41 is held in a pressing state in which the roller 44 slightly presses an intermediate portion of the tube 24 against the inner wall 31a of the case 31.

Cleaning of the recording head 16 by the head cleaning device 21 will hereafter be explained. First, the carriage 12 is moved to a cleaning position in the exterior of the image

forming area of the inkjet recording apparatus 10. The cap 22 of the cap mechanism 23 is then lifted to a position tightly fitted to the nozzle forming surface of the recording head 16, forming a sealed space. The drive force of the non-
5 illustrated motor is then transmitted to the rotary shaft 43 of the disk 42, and the pressing device 41 starts to rotate in a counterclockwise direction indicated by arrow D2 of Fig. 12 (a positive revolving direction in which the roller 44 moves from the upstream portion 24a of the tube 24, or the side of
10 the recording head 16, to the downstream portion 24b, or the side of the discharged ink reservoir 26).

Since the roller 44 presses the tube 24 at this stage, a friction force acts on the tube 24 in a clockwise direction.
15 The roller 44 is thus guided in the guide groove 55 of the disk 42 as following the relative rotation of the tube 24. In this manner, the roller 44 is rotated and revolved (rolled) to the operating position S, or the distal end of the guide groove 55.

20 Since the roller 44 is prohibited from moving further beyond the distal end of the guide groove 55 of the disk 42, the roller 44 is maintained at the operating position S and is rotated (turned) clockwise at this position. Thus, the roller
25 44 continuously presses and squeezes an intermediate portion of the tube 24 against the inner wall 31a of the case 31, shifting the pressing position of the tube 24 along the positive (counterclockwise) revolving direction indicated by arrow D2 of Fig. 12. If the roller 44 is held at the position
30 S and the reactive force produced by the tube 24 in the pressed state is increased, the roller 44 is displaced toward the axis A of the disk 42 by the resilient force of the coil spring 61. The increased force is thus absorbed. This structure allows the roller 44 to press the tube 24 with a
35 stable pressing force.

In this manner, by changing the volume of the interior of the tube 24, the tube pump 25 depressurizes the portion of the tube 24 at the side of the recording head 16 with respect to the roller 44, or the upstream portion 24a, which is the suction side. Negative pressure is thus produced in the sealed space defined by the cap 22, such that ink or gas is drawn from the nozzle of the recording head 16. Meanwhile, the tube pump 25 pressurizes the portion of the tube 24 at the side of the discharged ink reservoir 26 with respect to the roller 44, or the downstream portion 24b, which is the discharge side. The ink or gas drawn from the nozzle of the recording head 16 is thus urged to be discharged to the discharged ink reservoir 26.

With reference to Fig. 13, during this positive revolving operation, the tube pump 25 repeatedly passes the point at which one portion of the flexible tube 24 is abutted by another in the vicinity of the opening 32 (the point corresponding to the first and second portions).

In this state, if the outer circumferential surface of the tube 24 approaches the axis A of the disk 42 and the reactive force of the tube 24 is decreased, the roller 44 pivots separately from the axis A of the disk 42, such that the resilient force of the coil spring 61 compensates the decreased force. The roller 44 thus presses the tube 24 effectively.

Further, the case 31 includes the auxiliary member 101, the base surface (auxiliary surface) 101c of which is connected smoothly with the outer circumferential surface of the portion of the tube 24 passed through the opening 32. When passing the vicinity of the opening 32, the roller 44 moves first from the outer circumferential surface of the

downstream portion 24b (more specifically, the second portion) to the base surface 101c of the auxiliary member 101. Then, as elastically deforming the auxiliary member 101, the roller 44 moves from the base surface 101c of the auxiliary member 101 to the outer circumferential surface of the upstream portion 24a (more specifically, the first portion). Therefore, the roller 44 is capable of avoiding an impact otherwise caused by moving from the outer circumferential surface of the downstream portion 24b to the outer circumferential surface of the opposed, upstream portion 24a, which have different surface conditions. Further, while elastically deforming the auxiliary member 101, the roller 44 presses and squeezes the upstream portion 24a and the downstream portion 24b that are passed through the opening 32, against the inner wall 31a at opposite sides of the opening 32. The roller 44 thus prevents the negative pressure in the tube 24 from being released.

Thus, when the pressing device 41 is revolved in the positive revolving direction, the tube pump 25 suppresses the noise production due to the impact between the roller 44 and the tube 24, which noise would be otherwise repeatedly brought about. Further, regardless of at which position the roller 44 is located in the case 31, the roller 44 is constantly held in the state pressing an intermediate portion of the tube 24. In other words, the tube pump 25 prevents the negative pressure in the tube 24 between the recording head 16 and the discharged ink reservoir 26 from being released. Also, the tube pump 25 repeatedly revolves the roller 44 silently, such that the negative pressure in the tube 24 is gradually accumulated. This structure ensures a smooth cleaning operation of the head cleaning device 21.

After finishing the cleaning operation, as illustrated in Fig. 14, the head cleaning device 21 rotates the pressing

device 41 of the tube pump 25 in the direction indicated by arrow D3 of Fig. 14 (the reverse revolving direction), guiding the roller 44 in the guide groove 55 of the disk 42. In this state, the roller 44 is rotated (turned) counterclockwise by the friction force between the roller 44 and the tube 24. The roller 44 is thus rolled (revolved) to the retreat position T, located at the proximal end of the groove 55. Therefore, at the retreat position T, which is most spaced from the inner wall 31a of the case 31, the roller 44 releases the force acting to press the tube 24. The tube 24 and the auxiliary member 101 are thus protected from deterioration due to pressing and deformation when the non-cleaning operation is not performed.

As described above, in the illustrated embodiment, the roller 44 of the pressing device 41, which presses and squeezes the flexible tube 24 against the inner wall 31a of the case 31, moves along the base surface 101c (the auxiliary surface) of the auxiliary member 101 connected smoothly with the outer circumferential surface of the tube 24, when passing the vicinity of the opening 32 through which the tube 24 is passed. In this state, the roller 44 is revolved as deforming both of the tube 24 and the auxiliary member 101.

Therefore, although the condition of the outer circumferential surface of the tube 24 is greatly varied in the vicinity of the opening 32 of the case 31, the roller 44 suppresses the noise production, which would otherwise be caused repeatedly by the impact between the roller 44 and the upstream portion 24a to which the roller 44 is transferred. Further, while maintaining the negative pressure in the tube 24, the roller 44 is repeatedly transferred from the downstream portion 24b to the upstream portion 24a, passing the vicinity of the opening 32 of the case 31.

Accordingly, the tube pump 25 effectively draws ink from the recording head 16 without generating a noise such as the one caused by the impact. Further, the tube pump 25 completes the cleaning operation of the inkjet recording apparatus 10
5 efficiently and silently.

Figs. 15 and 16 show an example of an inkjet recording apparatus, a second embodiment of a liquid injection apparatus having a tube pump according to the present invention. Since
10 the second embodiment is configured substantially identical with the first embodiment, the same or like reference numerals are given to parts of the second embodiment that are the same or like corresponding parts of the first embodiment. Only the characteristics of the second embodiment will be described
15 herein (the remaining embodiments will be described in the same manner).

As shown in Fig. 15, the accommodating case 31, which is a constituent of the tube pump 25 of the head cleaning device
20 21 of the inkjet recording apparatus 10, includes an auxiliary member 111, in place of the auxiliary member 101 of the first embodiment.

Like the auxiliary member 101, the auxiliary member 111
25 is shaped as a substantially triangular pole with the axial dimension equal to that of the inner wall 31a of the case 31. However, unlike the auxiliary member 101, the auxiliary member 111 is formed from an elastic material with hardness sufficient for suppressing major deformation.

30 In the substantially same manner as the auxiliary member 101 of the first embodiment, the auxiliary member 111 includes a triangular cross-sectional shape that extends along the inward portions of the outer circumferential surface of the
35 tube 24 passed through the opening 32 in the case 31. The

auxiliary member 111 includes two slanted sides 111a, 111b of the triangular shape and a base surface 111c, which is located between the slanted sides 111a, 111b.

5 The slanted sides 111a, 111b of the auxiliary member 111 are formed as flat surfaces. The base surface 111c of the auxiliary member 111 is formed as a flat surface substantially parallel with the extended plane 35 extended from the inner wall 31a at the position corresponding to the opening 32. The
10 base surface 111c serves as an auxiliary surface connected smoothly with the inward portions of the outer circumferential surface of the tube 24 passed through the opening 32 in the case 31. The slanted sides 111a, 111b may be formed as curved surfaces as in the case of the first embodiment. However, the
15 slanted sides 111a, 111b are formed as the flat surfaces for obtaining sufficient strength for pivotal movement of the auxiliary member 111, as will be later described later. The tube pump 25 including the auxiliary member 111 may be assembled in the same manner as the first embodiment.

20

The auxiliary member 111 is pivotally supported by a pivot shaft 112, located inward from a position corresponding to the opening 32 of the case 31 and in the vicinity of the point between the slanted sides 111a, 111b.

25

Thus, when the tube pump 25 is operated in accordance with the positive revolution (the cleaning operation of the head cleaning device 21) and the roller 44 is located in the vicinity of the opening 32 of the case 31, the roller 44
30 contacts and pivots the auxiliary member 111 in a counterclockwise direction of Fig. 16 (in a second direction), as indicated by the solid lines. The roller 44 then proceeds to the base surface 111c connected smoothly with the outer circumferential surface of the downstream portion 24b. The
35 roller 44 then moves further in a direction away from the

opening 32 of the case 31 and past the pivot shaft 112. At this stage, or when the roller 44 moves past the line connecting the revolution axis A with the pivot shaft 112 (the pivot axis), the roller 44 quickly pivots the auxiliary member 111 in a clockwise direction of Fig. 16 (in a first direction). The roller 44 then moves from the base surface 111c to the outer circumferential surface of the upstream portion 24a connected smoothly with the base surface 111c.

More specifically, as pivoted by the roller 44, the slanted side 111b of the auxiliary member 111 presses the downstream portion 24b pressed by the roller 44 against the inner wall 31a of the case 31, with respect to the portion of the inner wall 31a corresponding to the associated one of the sides of the opening 32. In this state, the auxiliary member 111 allows the roller 44 to transfer to the base surface 111c.

When the roller 44 moves further in the direction away from the opening 32 of the case 31 along the base surface 111c, the pivotal direction of the auxiliary member 111 is quickly reversed. In this state, while pressing the upstream portion 24a between the slanted side 111a and the portion of the inner wall 31a of the case 31 corresponding to the opposing side of the opening 32, the auxiliary member 111 allows the roller 44 to return to the upstream portion 24a.

Therefore, when the roller 44 passes the vicinity of the opening 32 of the case 31, the auxiliary member 111 minimizes the time in which the pressing of the tube 24 is suspended, thus preventing the negative pressure in the tube 24 from being released. In other words, the roller 44 suspends the pressing of the tube 24 only instantly and slightly when passing in the vicinity of the opening 32. The roller 44 is thus smoothly transferred from the downstream portion 24b to the upstream portion 24a.

At this stage, like the first embodiment, the roller 44 proceeds to the opposed position of the tube 24 via the base surface 111c of the auxiliary member 111. This suppresses the impact between the roller 44 and the outer circumferential surface of the tube 24 to which the roller 44 is transferred, which impact would otherwise be caused by the varied surface condition of the inward portions of the outer circumferential surface of the tube 24 in the case 31. Further, after the roller 44 returns to the outer circumferential surface of the upstream portion 24a, the auxiliary member 111 receives the recovering resilient force of the tube 24 from both of the upstream portion 24a and the downstream portion 24b. The auxiliary member 111 is thus pivotally returned to a neutral posture, suspending the pressing of the tube 24.

In this manner, the tube pump 25 prevents the negative pressure in the tube 24 between the recording head 16 and the discharged ink reservoir 26 from being released. Also, the tube pump 25 repeatedly revolves the roller 44 without producing a noise, such that the negative pressure in the tube 24 is gradually accumulated. This structure ensures a smooth cleaning operation of the head cleaning device 21.

As has been described, the second embodiment has the same operational effects as those of the first embodiment. The tube pump 25 is thus capable of performing the cleaning operation of the inkjet recording apparatus 10 efficiently and silently. In addition, since the auxiliary member 111 is relatively hard as compared to the auxiliary member 101 of the first embodiment, damages caused by repeated elastic deformation are reduced. The auxiliary member 111 thus has an improved durability.

Figs. 17 and 18 show an example of an inkjet recording

apparatus, a third embodiment of a liquid injection apparatus including a tube pump according to the present invention.

As shown in Fig. 17, the accommodating case 31, which is
5 a constituent of the tube pump 25 of the head cleaning device 21 of the inkjet recording apparatus 10, includes an auxiliary member 111, in place of the auxiliary member 111 of the second embodiment.

10 Like the auxiliary member 111, the auxiliary member 121 is shaped as a substantially triangular pole with the axial dimension equal to that of the inner wall 31a of the case 31. The auxiliary member 121 is formed from an elastic material with hardness sufficient for suppressing major elastic
15 deformation.

In the substantially same manner as the auxiliary member 111 of the second embodiment, the auxiliary member 121 includes a triangular shape that extends along the inward
20 portions of the outer circumferential surface of the tube 24 passing through the opening 32 in the case 31. The auxiliary member 121 includes two slanted sides 121a, 121b and a base surface 121c, which is located between the slanted sides 121a, 121b.

25 More specifically, the slanted sides 121a, 121b of the auxiliary member 121 are formed as flat surfaces. The base surface 121c of the auxiliary member 121 is formed as a flat surface substantially parallel with the extended plane 35
30 extended from the inner wall 31a at the position corresponding to the opening 32. The base surface 121c serves as an auxiliary surface connected smoothly with the inward portions of the outer circumferential surface of the tube 24 passed through the opening 32 in the case 31. The slanted sides
35 121a, 121b may be formed as curved surfaces as in the case of

the first embodiment. However, the slanted sides 121a, 121b are formed as the flat surfaces for ensuring sufficient strength for sliding of the auxiliary member 121, as will be described later. The tube pump 25 including the auxiliary member 121 may be assembled in the same manner as the first and second embodiments.

The auxiliary member 121 has a slide groove 122 extending vertically from the vicinity of the point between the slanted sides 121a, 121b to the vicinity of the base surface 121c. A slide shaft 123 is located inward from the position corresponding to the opening 32 of the case 31. The slide shaft 123 is received in the slide groove 122. More specifically, the auxiliary member 121 maintains the base surface 121c in a state substantially parallel with the extended plane 35 extended from the inner wall 31a at the position corresponding to the opening 32 of the case 31. In this state, the auxiliary member 121 is capable of sliding together with the slanted sides 121a, 121b and the base surface 121c selectively toward or from the opening 32 of the case 31. In the third embodiment, only the case in which the auxiliary member 121 slides linearly will be explained. However, like the auxiliary member 111 of the second embodiment, the auxiliary member 121 may be pivotally supported.

Thus, when the tube pump 25 is operated in accordance with the positive revolution (the cleaning operation of the head cleaning device 21) and the roller 44 is located in the vicinity of the opening 32 of the case 31, the roller 44 contacts and slides the auxiliary member 121 toward the opening 32, as indicated by the solid lines in Fig. 18. The roller 44 then proceeds to the base surface 121c connected smoothly with the outer circumferential surface of the downstream portion 24b. Afterwards, as moving further in the

direction away from the opening 32 of the case 31, the roller 44 is transferred from the base surface 121c of the auxiliary member 121, which is held at a position close to the opening 32, to the outer circumferential surface of the upstream portion 24a connected smoothly with the base surface 121c.

In other words, as slid by the roller 44, the slanted sides 121a, 121b of the auxiliary member 121 press the tube 24 pressed by the roller 44 against the inner wall 31a of the case 31, with respect to the portions of the inner wall 31a corresponding to opposite sides of the opening 32. In this state, the auxiliary member 121 allows the roller 44 to be transferred to the base surface 121c.

When the roller 44 moves along the base surface 121c further in the direction away from the opening 32 of the case 31, the auxiliary member 121 returns the roller 44 to the upstream portion 24a, while pressing the tube 24 between the slanted sides 121a, 121b and the portions of the inner wall 31a corresponding to the opposite sides of the opening 32.

Therefore, when the roller 44 passes the vicinity of the opening 32 of the case 31, the tube 24 is maintained in a pressed state, thus preventing the negative pressure in the tube 24 from being released.

At this stage, like the first and second embodiments, the roller 44 is transferred to the opposed position of the tube 24 via the base surface 121c of the auxiliary member 121. This suppresses the impact between the roller 44 and the outer circumferential surface of the tube 24 to which the roller 44 is transferred, which impact would otherwise be caused by the varied surface condition of the outer circumferential surface of the tube 24 along which the roller 44 is moving. Further, after the roller 44 returns to the outer circumferential

surface of the upstream portion 24a, the auxiliary member 121 receives the recovering resilient force of the tube 24 from both of the upstream portion 24a and the downstream portion 24b. The auxiliary member 121 is thus retreated to a position spaced from the opening 32 and suspends the pressing of the tube 24.

In this manner, the tube pump 25 prevents the negative pressure in the tube 24 between the recording head 16 and the discharged ink reservoir 26 from being released. Also, the tube pump 25 repeatedly revolves the roller 44 silently, such that the negative pressure in the tube 24 is gradually accumulated. This structure ensures a smooth cleaning operation of the head cleaning device 21.

As has been described, the third embodiment has the same operational effects as those of the first and second embodiments. The tube pump 25 is thus capable of performing the cleaning operation of the inkjet recording apparatus 10 efficiently and silently. In addition, the auxiliary member 121 is relatively hard, as compared to the auxiliary member 101 of the first embodiment, and thus has an improved durability. Further, when the roller 44 passes the vicinity of the opening 32 of the case 31, the auxiliary member 121 reliably maintains the pressed state of the tube 24. The negative pressure in the tube 24 is thus accumulated, and the cleaning operation of the head cleaning device 21 is completed smoothly.

The accommodating case 31 does not necessarily have to be circular but may be oval or have other shapes, as long as the case 31 is provided with smoothly connected inner wall surfaces. Also, the case 31 does not necessarily have to have a single opening 32, through which the tube 24 is passed, but may have two or more openings 32.

Although the examples of an inkjet recording apparatus having a liquid injection apparatus have been explained in the illustrated embodiments, the present invention is not

5 restrictive to the embodiments. The present invention may be employed in, for example, an injection apparatus for electrode materials or coloring materials, which is used in the manufacture of liquid crystal or EL displays.

10 As is clear to those skilled in the art, the present examples and embodiments are to be considered as illustrative and not restrictive and the invention is not to be limited to the details given herein, but may be modified within the scope and equivalence of the appended claims, without departing from
15 the scope of the present invention.